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UNDERSTORY HARDWOODS RETARD GROWTH LEAF PINE IN MISSOURI

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SHORTLEAF PINE IN MISSOURI

This is the second in a series of three publications on the management of shortleaf pine in the Missouri Ozarks. The other two are: *Stand Density Affects Yield*, and *Two Methods of Thinning*.

The natural range of shortleaf pine in Missouri covers about 7 million acres in the east and south-central part of the Ozarks. The forest land here is characterized by rough topography and shallow, rocky, infertile soils. Summer droughts are common in spite of average annual precipitation in excess of 40 inches. As a result, some sites are too poor to produce high-quality hardwood timber. Many of these sites, however, if properly managed, could grow good crops of pine. We have prepared this series of publications to facilitate management of shortleaf pine on such sites in the Missouri Ozarks. The information presented represents the 10-year results of our pine studies.

The authors gratefully recognize the leadership of Dr. Franklin G. Liming in implementing the study upon which this manuscript is based. His efforts in shortleaf pine research in Missouri are now bearing results. Dr. Liming is currently on the staff of the Division of Timber Management Research, U.S. Forest Service, Washington, D.C.

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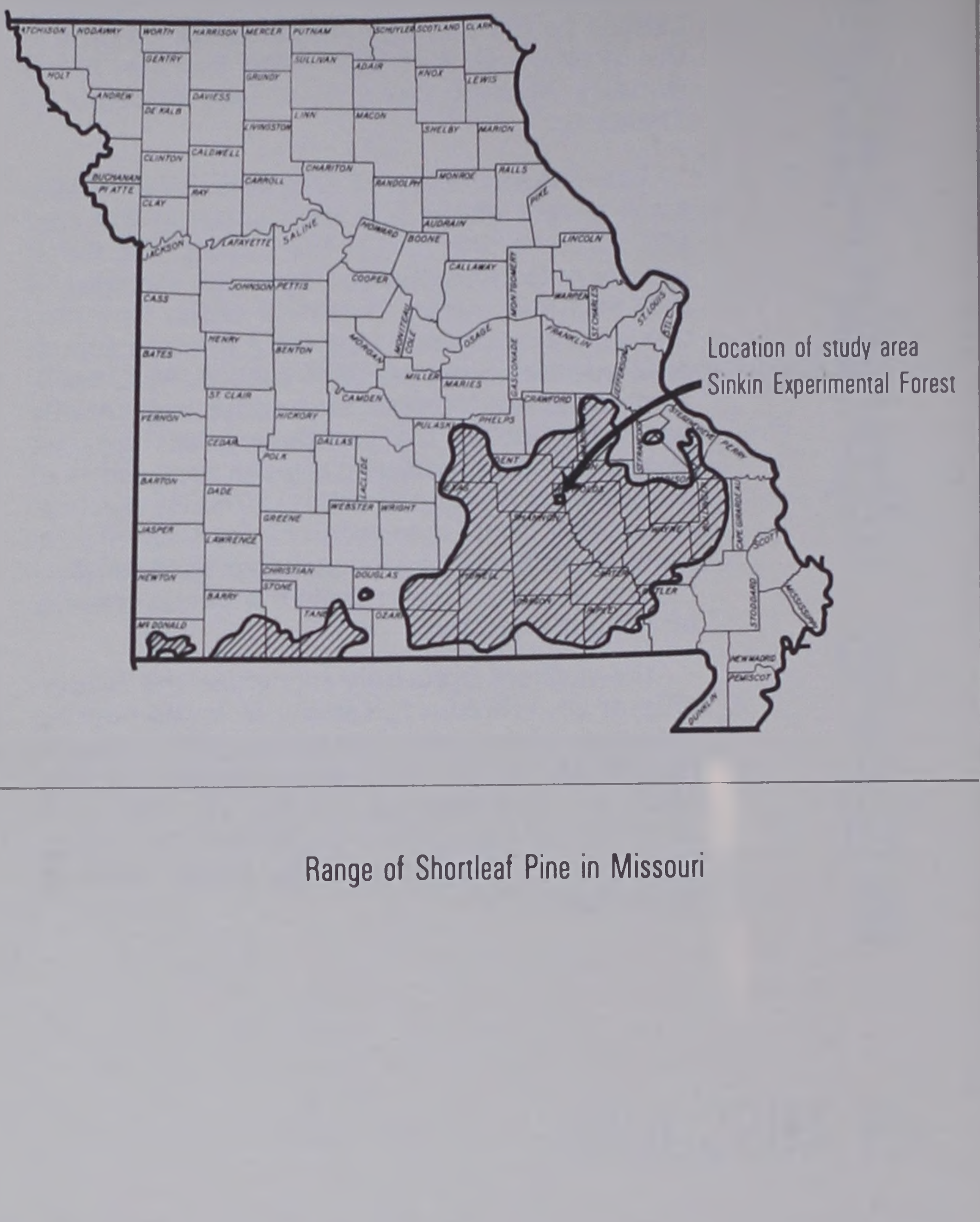

Location of study area
Sinkin Experimental Forest

Range of Shortleaf Pine in Missouri

Shortleaf Pine in Missouri

UNDERSTORY HARDWOODS RETARD GROWTH

Nelson F. Rogers

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Summer droughts frequently limit the growth of forest trees on the rocky soils of the Missouri Ozarks. So an important objective in improvement cutting and thinning shortleaf pine (*Pinus echinata* Mill.) stands is to reduce competition for available soil moisture. However, in current operations small hardwoods are usually left even though they can be controlled with modern herbicides without damaging the pine. A recent study shows that eliminating *all* hardwoods sharply increases growth in pine stands. Pine growth increased enough in 10 years to more than offset the cost of hardwood control.

Maintaining reasonably good growth during the frequent periods of summer drought is a problem common to the management of any Ozark forest. Although annual rainfall is 40 to 48 inches, the shallow, rocky soils have a limited capacity for storing moisture. So competition for soil moisture becomes acute nearly every summer.

Competition among pines can be reduced by thinning the pine stand. Reducing competition from hardwoods by eliminating them has been shown to conserve summer moisture in pine stands.[1] But how will this affect growth of the pine? Our study was designed to find out.

THE STUDY AREA

The study was conducted in a pine-oak stand on the Sinkin Experimental Forest, Dent County, Missouri. The stand is located on the tops and sides of two main ridges. Slope ranges from 4 to 30 percent. The soil is classified as Clarksville stony loam. Site index is 60 to 65, about average for shortleaf pine in Missouri.

The stand developed naturally after harvest of an oak-pine stand about 1918. Since 1933 this area has been a part of the Clark National Forest and has not been burned. Most hardwood trees in the stand were cut or girdled in 1934 and the pines were thinned from about 1,100 to 600 trees per acre.

This early thinning eliminated the poorest pine trees, removed most competing hardwoods, and left the better pine trees free to grow. By 1951, however, the need for another thinning was indicated by reduced diameter growth, complete crown closure, and the presence of many overtopped pine trees.

Pine trees ranged in diameter from 1 to 12 inches, averaging 6.4 inches. Dominant and codominant trees were about 50 feet tall. Pine basal area averaged 138 square feet per acre.

Most hardwoods had resprouted by 1951 — when the stand was about 30 years old. The stands contained about 900 hardwoods per acre 0.6 inch d.b.h. and larger with a basal area of 14 square feet. In addition, there were about 3,500 smaller hardwood stems per acre. The most numerous understory species were black oak *(Quercus velutina* Lam.), white oak *(Q. alba* L.), sassafras *(Sassafras albidum* (Nutt.) Nees), and dogwood *(Cornus* L. spp.).

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[1]Zahner, Robert. HARDWOOD UNDERSTORY DEPLETES SOIL WATER IN PINE STANDS. Forest Sci. 4: 178-184, illus. 1958.

THE STUDY

The effect of controlling hardwoods on the growth rate of pine was determined in both thinned and unthinned natural pine stands.

Thinned Stands

Six plots, ½ acre in area and surrounded by ½-chain isolation strips, were thinned in the spring of 1951 to 70 square feet of basal area per acre. This left about 220 pine trees per acre containing 4,260 board feet (International ¼-inch rule) or 1,240 cubic feet.

Selective thinning left the best possible pine trees, those with single, straight, well-formed boles (fig. 1). Most crowns were full and vigorous, occupying from one-third to one-half of total tree height. In general, the larger trees were left, but good spacing was a major goal in this thinning.

FIGURE 1. — Thirty-year-old shortleaf pine stand before thinning showing many small hardwoods.

FIGURE 2.— After pine stands were thinned and large hardwoods cut, the foliage of hardwood sprouts was sprayed with 2,4,5-T in water.

In three of the six thinned plots all hardwoods 0.6 inch in d.b.h. and larger were cut in 1951. All hardwood foliage was sprayed with herbicide in the spring of 1952 (fig. 2). Surviving hardwoods were sprayed again in 1955 and 1959.

In the other three plots only the large hardwoods (3.6 inches d.b.h. and larger and/or more than half the height of pines) were cut. More than 3,000 hardwoods smaller than 0.6 inch d.b.h. were left plus about 485 one to three inches d.b.h. These hardwoods added 4 square feet of basal area increasing the total to 74 square feet per acre.

Ten years later, after the 1960 growing season, pine stocking in thinned stands was again reduced to 70 square feet of basal area per acre.

Unthinned Stands

Pine stocking in the six unthinned plots averaged 590 trees with about 142 square feet of basal area per acre. Volume averaged 6,500 board feet or 2,368 cubic feet per acre. This is typical of well-stocked natural stands of this age in the area.

As in the thinned stands, all hardwoods were killed in three plots; all hardwoods were left regardless of size in the three other unthinned plots. This amounted to 779 hardwoods with 13 square feet basal area, plus 2,200 smaller trees per acre.

RESULTS AFTER FIRST 10 YEARS

After 10 years, it was evident that controlling hardwoods in pine stands significantly increases basal-area and volume growth of the pine. Thinning the pine further increases its growth.

Basal-Area Growth

Hardwood control increased the basal-area growth of both thinned and unthinned pine more than 9 square feet per acre in 10 years (table 1). Where hardwoods were left, about 8½ square feet per acre were added to the hardwood basal area instead of the pine.

In thinned stands without complete hardwood control, the measurable basal area of hardwoods left was only 4.2 square feet per acre. Killing all hardwoods in such stands increased basal-area growth 34 percent. On the other hand, in similar pine stands where hardwoods were controlled, leaving as much as 110 square feet of basal area did not materially change basal-area growth.

How could such a small amount of hardwood have such a great effect on pine growth? The secret is in the hardwoods that are too small to be measured but large and numerous enough to result in a serious drain on soil moisture and nutrients. This suggests that the basal area of hardwood trees 0.6 inch d.b.h. and larger is an inadequate measure of total stocking.

Volume Growth

In thinned plots with no hardwoods, pine gained 990 cubic feet in volume per acre in 10 years, more than under any other treatment (table 2). This was nearly 40 percent more than for thinned pine where hardwoods were left and 72 percent more than for unthinned pine on plots where hardwoods were left. Killing small hardwoods thus greatly increased pine volume growth. This is direct evidence of the growth-retarding effect a hardwood understory has even in thinned stands.

Table 1.--Change in shortleaf pine stands (including mortality) from 1951 to 1961 thinnings and growth during the 10 years (data include trees 0.6 inch d.b.h. and larger)

	Thinned stands		Unthinned stands	
	No hardwoods left	Understory hardwoods left	No hardwoods left	All hardwoods left
NUMBER OF TREES PER ACRE				
Pine				
Cut 1951	399	333	--	--
Left 1951	225	209	597	586
Stand 1961	224	205	559	520
Cut 1961	93	69	--	--
Left 1961	131	136	559	520
Hardwoods				
Cut 1951	1,092	356	1,113	--
Left 1951	--	485	--	779
Stand 1961	--	806	--	781
BASAL AREA IN SQUARE FEET PER ACRE				
Pine				
Yield 1951	68.5	68.8	--	--
Left 1951	70.2	69.8	138.2	146.8
Growth 10 years[1]	38.5	28.7	34.9	25.7
Yield 10 years[1]	39.0	28.3	3.3	6.6
Left 1961	69.7	70.2	169.8	165.9
Total production[2]	177.2	167.3	173.1	172.5
Hardwoods				
Cut 1951	15.2	4.8	14.4	--
Left 1951	--	4.2	--	13.2
Growth 10 years[1]	--	8.4	--	8.4
Left 1961	--	12.0	--	19.5

1/ Includes mortality.
2/ Sum of 1951 and 1961 yields plus the stand left in 1961.

In unthinned pine plots, removing all hardwoods increased pine volume growth about 41 percent, from 575 to 810 cubic feet per acre. Hardwood control in these unthinned plots had reduced total basal area about 9 percent. But the difference in volume growth far exceeds that found in a related study where pine stocking was the

Table 2.--Total growth and yield of shortleaf pine (including mortality) from 1951 through 1961

CUBIC FEET PER ACRE[1]

	Thinned pine stands		Unthinned pine stands	
	No hardwoods left	Understory hardwoods left	No hardwoods left	All hardwoods left
Yield 1951	960	1,070	--	--
Left 1951	1,230	1,250	2,290	2,445
Growth 10 years[2]	990	710	810	575
Yield 10 years[2]	780	545	30	40
Left 1961	1,440	1,415	3,070	2,980
Total production[3]	3,180	3,030	3,100	3,020

BOARD FEET PER ACRE[4]

Yield 1951	1,670	2,665	--	--
Left 1951	4,080	4,445	6,160	6,845
Growth 10 years[2]	5,950	4,230	4,825	3,505
Yield 10 years[2]	3,290	2,215	50	45
Left 1961	6,740	6,460	10,935	10,305
Total production[3]	11,700	11,340	10,985	10,350

1/ Gross peeled volume in cubic feet to a 3-inch top (d.i.b.).

2/ Includes mortality.

3/ Sum of 1951 and 1961 yields plus the volume left in 1961.

4/ Gross volume in board feet (International 1/4-inch rule) to a 5-inch top (d.i.b.).

only variable considered. This again emphasizes that understory hardwoods too small to contribute much to total basal-area stocking seriously compete with pine.

Ingrowth in 10 years was negligible in terms of cubic feet. But in board feet, it amounted to 400 per acre in thinned plots and 1,120 in unthinned plots where more small trees were left. Ingrowth will be an important part of total growth in unthinned plots for many years.

Current growth rates do not reliably indicate what can be expected during the balance of the rotation. Height growth still is fairly rapid at this age, and changes in merchantable height and form class contribute greatly to total growth. But with increasing age, most volume growth will be caused by increases in tree diameter.

Mortality

A few pine trees died from various causes in all stands during the 10 years. In unthinned plots, however, many pines died because of competition for moisture and light. This was particularly true where all hardwoods were left; 66 pine trees died here compared with 38 where hardwoods were eliminated.

VALUE OF HARDWOOD CONTROL AND THINNING

Intensive hardwood control in pine stands could be considered expensive: about $34 per acre was invested in the 10 years. But stumpage value of products sold from trees cut in 1961 was $30 per acre more on thinned plots without hardwoods than on plots where the understory hardwoods were left. And this cutting removed only 60 percent of the increase in volume resulting from hardwood control. Total value of this extra growth was about $47 per acre, more than enough to repay the costs of killing the hardwoods. Better techniques and herbicides no doubt will reduce such costs in the future. Something less than complete control of hardwoods would effectively increase pine volume growth. But this study shows that cutting only the larger hardwoods is not enough.

In unthinned pine stands, the gross value of the added volume due to hardwood control was about $34 per acre in 10 years. Of course, hardwood control in fully stocked young pine stands without thinning the pine is not recommended.

In general, where a dense hardwood understory is expected to hinder natural pine regeneration, eliminating hardwoods in conjunction with pine thinning is an excellent management practice. The immediate cost of killing hardwoods should be covered by returns from thinning, and increased pine volume growth because of hardwood control should soon repay deferred income and interest on it.

The average pine volume growth on all thinned plots was about 22 percent higher than on all unthinned plots. However, hardwood control had more effect on growth rate than thinning.

Thinning had other benefits that may be important to the forest manager. Growing-stock investment was smaller and proceeds from the sale of products were available to repay costs of hardwood control or to be used for other purposes.

During the period 1951 through 1961, the six thinned plots yielded about 1,675 cubic feet (4,920 board feet) per acre in two cuttings. Stumpage sold averaged $126 per acre. Average growth in the six unthinned plots during this period was 158 cubic feet (925 board feet) per acre less than in the thinned stands. Total volume produced in 10 years was nearly 1,000 board feet per acre more in thinned than in unthinned pine stands.

SUMMARY

Killing all hardwoods increased volume growth in both thinned and unthinned shortleaf pine stands in Missouri about 40 percent in 10 years. Thinned pine without hardwoods grew nearly 6,000 board feet per acre in the period, about 1,700 board feet more than where hardwoods were left and about 3,500 board feet more than unthinned pine where no hardwoods were killed. Second best growth was on unthinned plots where all hardwoods were controlled.

Extra pine volume added through hardwood control more than repaid costs. Eliminating hardwoods has prepared the sites for subsequent natural regeneration of pine. The current differences in growth are expected to continue. Thinned pine stands grew 22 percent more in volume than unthinned stands; thinning reduced the capital growing stock and provided intermediate yields. The combination of thinning pine and controlling hardwoods increased pine growth 72 percent over that of unthinned pine stands with hardwoods.

THE AUTHORS

NELSON F. ROGERS has been with the U.S. Forest Service for more than 30 years — 20 of them with the Central States Forest Experiment Station. Before beginning his research career he served on National Forests throughout eastern United States. Nelson is a graduate of the State University of New York College of Forestry. Although Rogers' primary responsibility is serving as Superintendent of the Station's Sinkin Experimental Forest near Salem, Missouri, his active participation in silvicultural research projects has resulted in more than a dozen publications.

KENNETH A. BRINKMAN began his Forest Service career at the Central States Station in 1938. He soon moved to Mississippi with the Southern Forest Experiment Station, then to Arizona with the Southwestern Station, then to Alabama with the Southern Station again. Finally, in 1948, he returned to the Central States and worked in Iowa until 1955. Since then he has been at our Columbia, Missouri, field office. A lieutenant in the Coast Guard during World War II, Brinkman was commanding officer of a sub-chaser and later a tanker. Ken got his forestry training in his native state of Iowa, earning B.S. and M.S. degrees at Iowa State University. He is a silviculturist specializing in regeneration, woody-plant control, and conversion of low-quality oak stands.